Wireless Binding Methodologies

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Abstract

Robust wireless systems require a well thought out method of establishing a connection between different elements in the system to enable communication, while prohibiting unwanted connection with devices outside the intended system. This application note discusses the general considerations for deciding on a binding methodology, and also walks through several examples of common binding schemes, highlighting their advantages and disadvantages. It is intended for system architects, particularly those that are relatively new to wireless designs.

Introduction

When connecting a wired peripheral to a host computer, 'binding' is a straightforward process. Essentially, if the cable can be detected, then the peripheral is recognized and therefore 'bound' to the host. For example, in the case of a USB peripheral, when the USB cable is plugged into the host PC, the cable connection is automatically detected through the D– or D+ pull-up resistor. The host sets a device address during enumeration, which is used to communicate with that specific peripheral in all further exchanges.

In the case of wireless systems, binding is a more complex process. Since there is no physical connection between elements, other methods must be employed to indicate that a connection is implied or desired. This is what we refer to as 'binding'. This application note discusses general considerations for establishing binding schemes and describes several methods for binding in WirelessUSB systems. Specific code is not provided—for firmware, it is best to go straight to the Cypress wireless reference designs.

In short, binding determines which RF elements should be able to communicate with one another. This is essential in environments where multiple wireless systems may exist in close proximity sharing the same RF band to communicate. A host may be able to hear wireless communications from many peripherals within its proximity, but it needs to be explicitly told which ones to listen to and which to ignore.

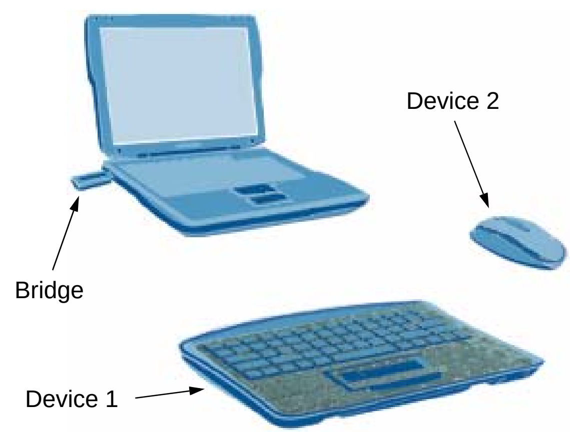
General Considerations

This section presents the definition of terms and the system requirements for wireless binding.

Definition of Terms

Wireless systems are very flexible in their topology with a specific solution typically being defined by the firmware implementation. Many of the systems that Cypress supports are PC-centric with one or more devices having an access point to a single PC. We will generally consider this topology, but the concepts discussed are applicable to other topologies.

Figure 1. Typical Wireless System



Bridge is the term that is used to describe the access point. In a PC-centric network this is a usually a small form factor device that attaches to the USB port. Thus it 'bridges' the data from the remote device to the PC. In embedded systems it may attach to another processor via a UART, SPI, or similar interface—or it may be the embedded device itself. In either case we are generally considering the center of the system.

Device is the term used to describe the element that is being added to the network. Examples include a mouse, keyboard, remote control unit, temperature sensor, actuator, and others. Typically, there will be one bridge, but one or more devices in a system.

The term binding has already been introduced, but be aware that other terms are also used in the industry to refer to essentially the same process. 'Pairing' is one of the more common terms. Cypress uses the ‘bind’ term to imply that the connection is generally of a more permanent nature. Usually, devices are bound once and there is no need to repeat the process during the life of the product. This may not be true in all applications.

System Requirements

This Application Note introduces some common binding methodologies, but in reality there are many variations on these themes. Choosing the right binding method is all about satisfying a particular end-user experience. There may be some give-and-take in this process, but defining the desired system and user goals will help to converge on a suitable implementation.

The Cypress solutions have multiple strengths. The first is that Cypress uses a 2-way communication between different points in the system, thus every transmission is acknowledged by the recipient. Cypress also uses a robust network protocol producing the industry's best interference immunity, as well as support for a vast number of co-located systems. This is accomplished in part by using diversity of channel, pseudo-noise (PN) code, and checksum seed to establish communication between elements on a given network. Some applications may choose to use other parameters—the Device ID assigned by our CY3635 N:1 kit is a good example. These are the parameters that must be established at bind time.

In order for the two elements to communicate for the first time, and thus establish the intent to join or form a network, they must be able to find each other using a common channel, PN code, and checksum seed at a specific point in time. This is the complicated problem that this application note endeavors to explore.

It is worth mentioning that robust protocols and binding schemes may not be necessary for all applications. In some cases it may be perfectly acceptable to fix one or more of these values, such as channel, or even to allow limited selection such as through a switch or pin strapping. Many of the console game controllers use a method like this today. Even 1-way communication might be suitable in some systems. In general these might be appropriate for non-consumer applications where the environment is well controlled and understood. These are simplistic enough that they will not be explored further in this application note.

User Action

For most applications there are a few factors that should be considered. The first is user action. In order to start using this new device, or to add it to an existing system, what action must the user take? Press a button? Follow a power-on sequence? Launch a software application? Try to use the device in a ‘normal’ fashion? Of course the goal is to make the process as simple and intuitive as possible—both to make life easy for the end user and also to reduce the cost of customer support calls when things do not go as expected. But ‘intuitive’ is a subjective thing, and may vary from application to application.

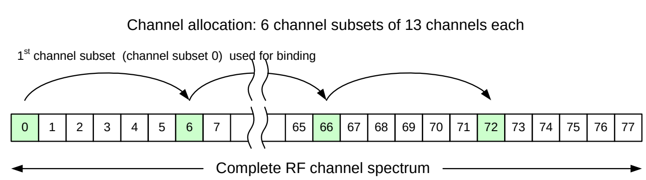
Sequence

The next thing to consider is whether or not a specific sequence has to be followed. Limiting the process to a specific user sequence of events (for example, first press the bind button on the bridge and then press the bind button on the device) could potentially simplify the process for the developer, or allow more flexibility on other aspects of the solution. It may also help to reduce or eliminate the timeout that is typically required—at least on one side of the system. This means that inadvertent activation of the bind process on this side may be almost imperceptible to the end user. The disadvantage is that the user has to remember or look up what the right sequence is. It also increases the likelihood of a technical support call to resolve the situation.

Protocol

Another consideration is related to protocol and network parameters. Again, the assumption is that customers will take advantage of the Cypress solution advantages, but that does not mean that our exact code has to be strictly followed. The primary goal of binding is to establish the right set of network parameters to enable ongoing communication. But how do you know where to initially go to conduct the bind sequence? The simplest method is to use a default set of parameters: for example, channel 0, default PN code, and 0 checksum seed. But what if there happens to be strong interference on channel 0 at the time? It may not be possible to successfully conduct the binding operation. Other alternatives are to introduce some level of protocol to enable variation of certain network parameters (typically the channel) to provide increased opportunities for the elements involved in the bind process to establish that initial communication.

Figure 2. Typical Implementation of Channel Subset for Binding



In these examples we also assume that the device is the one actively transmitting, that is attempting to get permission from the bridge to join the network. The bridge is the default receiver. Bear in mind that there may be applications where a different scheme may be more appropriate. For example, a bridge might periodically broadcast its network parameters, say once every few seconds, so that any device that is brought into range of the network can identify it and present the user with an opportunity to join.

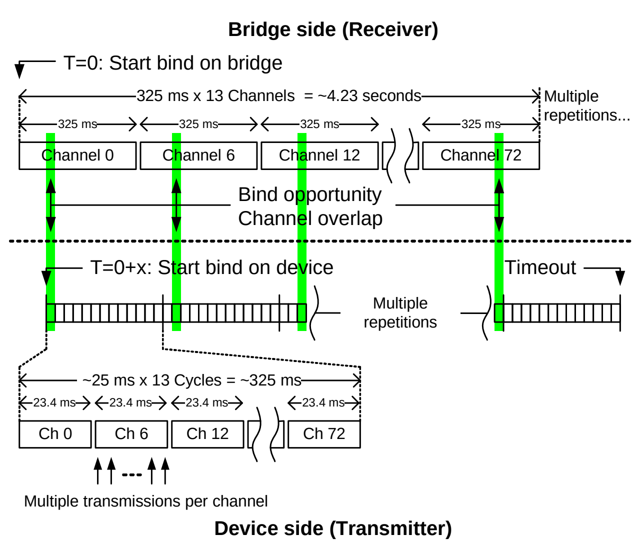
Timing

There are three aspects of timing to discuss. First of all, how long does the user have to take the necessary actions? The bind process typically interrupts normal device operation. A timeout (as brief as possible) is desired to handle cases where the bind fails or when it was inadvertently activated, but it needs to be long enough to be usable. Consider a system targeted at desktop PC users. The USB port may be on the back of the PC under the desk. Enough time has to be allowed to crawl under the desk, press the button on the PC and then to crawl back out and press the button on the device side—maybe 20 seconds.

The next thing to consider is how long until the user sees a response from the process. In many cases the response may be nearly instantaneous, but more complex binding schemes that allow more flexibility or more handling for interference may require additional time. A few seconds without a visual response may be enough for the user to be confused and therefore try to start the process again, even though the first attempt may still be in process.

And finally there are low-level timing considerations. In particular this applies to more robust schemes where network parameters are being varied to try to give a better chance to bind in the presence of interference. If you allow changing of channels (or other parameters) you have to carefully think through the sequence to make sure that there will be adequate time for both elements to find each other in a common place. This affects two things: the probability of successful completion of the process, and the length of time required for the user to see a response as described above.

Figure 3. Bind Timing Example



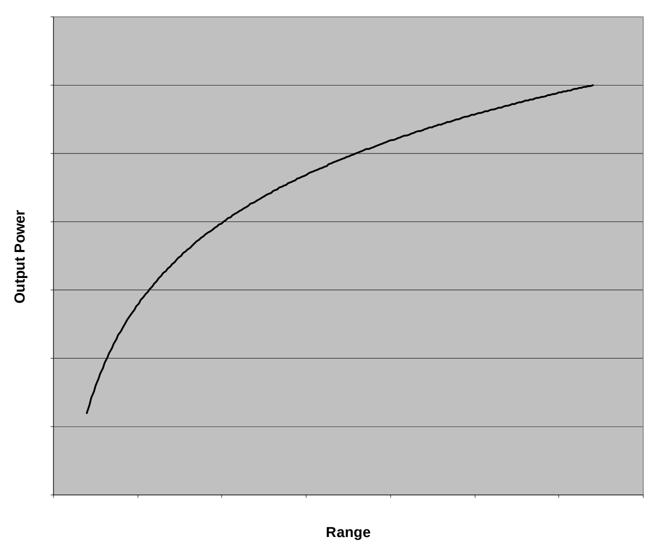
Range Discrimination

The reason that range can be an issue is that many products may support multiple co-located networks that are potentially in communication range of one another. Examples are keyboard/mouse products in an office environment, or building sensor networks. During the bind process there may be a risk of cross-binding—accidentally binding the device into the wrong system/network. It may not be obvious to the user what has happened or how to fix it. Limiting range can help to constrain this problem. One of the other likely places to encounter this issue is when trying to bind devices on the production line. With multiple units being bound in rapid succession and close proximity there is an increased potential for cross-binding.

Limiting range is usually not a problem for the end user. For most systems it is reasonable to assume that when configuring the system the user has the device to be bound in close proximity to the bridge. Limiting range can provide more control over the binding process. But there are applications where that might not be the case, such as with sensor networks in a building control system. In this case, maximum range may actually be helpful to the bind process.

The tricky part of this is that, although the user perceives distance, the wireless device generally does not have the ability to measure this directly. The wireless device senses signal strength, which can roughly correlate to range. Many factors can impact this, such as actual transmit power, interference, attenuation through walls or other material including product enclosures, multipath effects, antenna orientation, and others. So although it may be desirable to limit range generally this can only be done at a coarse level. As a simplification (considering only free-space signal spreading) a 6 dB delta in power roughly correlates to a 2X delta in range.

Figure 4. Typical Relationship of Output Power vs. Range



Calculation of Network Parameters

An example of key parameters that come from the binding process was provided above: channel, PN code, and checksum seed. The actual requirements for the parameters may vary by application—how many nodes are in a particular system, how many systems could potentially be co-located within communication range, and so on. Cypress has a couple of examples, the best of which comes from our 2-way HID protocol. More details can be found in the CY4636 User's Guide.

What source is used to generate these parameters? For most applications a random distribution across the target parameters is desired. Cypress typically uses the Manufacturing ID contained within the radio as a seed for calculating these numbers. This is a 6 byte value and, although not guaranteed to be unique, is unique enough for most applications to use it as a source for creating a diverse array of wireless networks

In particular the MID from the bridge device is typically used, since it is the central point in the network. A common algorithm is applied to all devices in the system so that if multiple devices are provided with the same MID, which is exchanged during the binding process, then all devices will arrive at the same selection of network parameters.

Figure 5. Sample Algorithm for Network Parameters

6 byte Manufacturing ID

MID 6	MID 5	MID 4	MID 3	MID 2	MID 1

PN Code = (MID1 << 2) + MID2 + MID3
Base Channel = (MID2 >> 2) - (MID1 << 5) + MID3
PIN = (((MID1 - MID2) & PIN_MASK) + MIN_PIN)
CRC Seed = ((MID2 >> 6)) + MID1 + MID3

Refer to the CY4636 User's Guide for a more thorough description of all parameters

In some cases it may be desirable to use a source other than the MID to seed the calculation of network parameters. Allowing a value to be specified, such as through a Windows dialog box, may allow a higher degree of end user control on the setup of the network. In other systems there might even be multiple bridges, such as with media center remote controls. A household might have one or more remote controls that interact with one or more PCs and set top boxes. In this case the system needs to account for the fact that there are multiple bridges, so the firmware may need to base the network parameters on a default bridge MID and allow overriding of the MID for the 2nd, 3rd, 4th, and other bridges in the household. Or it could establish a completely separate mechanism for establishing the seed value for the algorithm.

Storing Binding Parameters

There are two somewhat related topics here: where are the network parameters stored, and is there any way to get rid of them and start again?

In general the network parameters or the seed for the algorithm will be stored in nonvolatile memory. That way users do not have to rebind their systems any time power is removed—for example, to replace batteries or when the bridge is removed from the USB port of the PC. For most of Cypress's examples the information is stored by the device and not by the bridge. This allows many devices to communicate with one bridge without the bridge having to keep track of all devices. The bridge will talk to any device that knows its network parameters. The bridge's MID is used as the seed for the network parameter algorithm, so each device must store the MID of the bridge that they want to communicate with. The actual network parameters can be recalculated as needed from this base. The implication of this is that the bridge does not know which devices will talk to it unless additional firmware manages this. For some applications it may be desirable to have the bind parameters stored on the bridge side, or even on both sides.

The other question is basically "Can I un-bind?" For some systems this is unnecessary. A system using a button, for example, can initiate an attempt to bind with a new bridge whenever the button is pressed. But some systems may not use an explicit mechanism like this. For certain applications it might be valuable to provide some other mechanism for removing the previous bind parameters: removing and restoring power, a Windows application, or a special button.

Controlling the Number of Bound Devices

One last thing to consider is whether there needs to be a control on the number or types of devices that are bound. The Cypress HID design provides a good example. Parameters are stored only on the device side and not the bridge side. Therefore it is possible to have a large number of mice and keyboards all talking to the same bridge.

In some cases this might be good. For example, consider adding a presenter tool to the product portfolio. These tools typically appear as keyboard-type devices (page up, page down, esc keys, and so on). The presenter could easily be added to the system without any changes to existing product firmware, enabling it to appear like just another keyboard. But this flexibility also might make it easier to inadvertently cross-bind an unintended keyboard into the system.

Binding Methods

Having discussed some of the key concerns in determining a binding mechanism for a particular system, now specific implementations can be examined. The discussion will assume the capabilities of WirelessUSB LP are being used, but the same techniques can also be applied to WirelessUSB LS, LR, or other wireless systems, although the packet structure and content may vary. Here is a typical example.

The bridge device (the one controlling the binding) must be in a receive mode listening for a request. The device that is to be bound into the system sends out a packet indicating a bind request. Typically this might be indicated by a particular byte, such as the packet header. Other information can be passed in the remainder of the packet if required by the application. When the bridge receives the request it acknowledges it and sends a subsequent packet with the necessary data used to calculate the network parameters, which is then acknowledged by the device.

At this point, both sides of the system have the information to establish communication with the same set of network parameters so normal operation can begin.

Factory Binding

Although often overlooked, factory binding can have a big impact on the end user.

Description

The vendor supplying the product prebinds the devices during the manufacturing process and ships them together in the same package. Therefore, when the user receives the product he can just begin using it without any other action required. Factory binding usually does not exist on its own. Another binding method is typically provided with the product to enable the factory bind process and also as a backup for the end user. It is also possible to have outgoing test software that preloads the necessary values into nonvolatile memory.

Advantages

- Easiest method with highest chance of successful user experience. True plug-and-play. It just works out of the box
- Least risk of technical support calls, therefore smallest support cost
- No impact to power consumption in battery powered systems

Disadvantages

- Risk of cross-binding on the manufacturing line
- May require additional manufacturing steps, which adds a small amount of time and cost
- Not suitable for systems where additional devices can be sold independent of the bridge

2-Way Button Bind

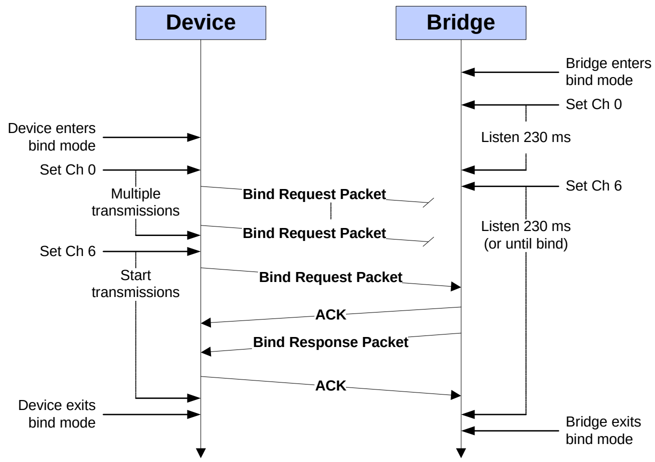
This is a common method of binding that is used on most Cypress WirelessUSB systems. It is straight forward and easy to use.

Description

Each side of the system (device and bridge) has a specific button used to initiate bind. In this scenario there is no required order in which to press the button. When the user presses the bind button on the bridge it is placed into a listening mode, ready to receive bind requests. When the button is pressed on the device side it begins continuous transmission of bind requests. Both sides have a timeout of about 20 seconds allowing ample time to press both buttons in the case that one is not in an easily accessible location. Furthermore, multiple channels are used to increase the chance of a successful bind. Both the bridge and the device must rotate through the defined subset of channels. A reduced output Power Amplifier (PA) level is used, which slightly limits the range but does not tightly constrain it. When the bridge receives the request it responds with the MID used to seed the network parameters algorithm at which point the sequence is complete.

Timing is similar to that shown previously in Figure 3. Sequencing is shown below.

Figure 6. Example Button Bind Sequence



Advantages

- Simple system resulting in good user experience. It is reasonably well understood by most users because it is commonly used

- Minimal risk of technical support calls
- Adequate time-out ensures users can get both bind buttons pressed even when one device is not quickly accessible. Buttons can be pressed in any order

Disadvantages

- Small cost impact for button hardware on both sides
- Ties up the system when the bind button is pressed due to the timeout required. This can be problematic in the case of inadvertent bind button presses
- Inexperienced wireless users may not understand the bind requirements and the need to press buttons before using the device for the first time—small potential for support calls

Derivatives

Software-initiated bind on bridge

Most of the systems that we are discussing connect through a central bridge to another processor (PC, set top box, and others). Instead of using a physical button it is possible to command the bridge into the bind mode through a software interface on the host. This just implements a ‘soft’ button so the process is otherwise exactly as described above.

Additional advantages

- Cost savings through elimination of button

Additional disadvantages

- Not obvious—requires user documentation and increases risk of tech support calls
- Increased development time/cost for host software

Reduced Timeout—Sequencing Requirement

There are various uses for a specific sequence, but the main one is allowing one side of the system to have a drastically reduced bind timeout. The other side typically retains the long timeout to allow the user adequate time to initiate bind on both sides of the system. Bind is initiated first on the side with the long timeout and then on the other side. Since the 2nd side knows that the first side is already in bind mode, it can expeditiously execute its own sequence, probably fast enough that any delay is not noticeable by the user. Completion of binding will appear almost instantaneously after the 2nd button press. A good example is a very small form factor bridge where the bind button may be accidentally pressed when inserting the bridge into the PC’s USB port.

Additional advantages

- Reduced timeout on one side—inadvertent bind button presses are imperceptible by user
- Bind power consumption on that side can be reduced

Additional disadvantages

- User must remember sequence or bind will fall

Power-up Bind

At the highest level power-up bind just means using the power-up process as a replacement for pressing a button.

Description

Every time power is applied to the unit with power-on bind implemented, it will enter a bind sequence. In some cases, such as those when power is infrequently removed, this will not appear substantially different from what has been discussed under 2-way button bind. In cases where it is likely for power to be cycled frequently this method is either not acceptable or there will have to be some changes to prevent it from becoming intrusive to normal device operation. The likely change is to reduce the timeout as described above.

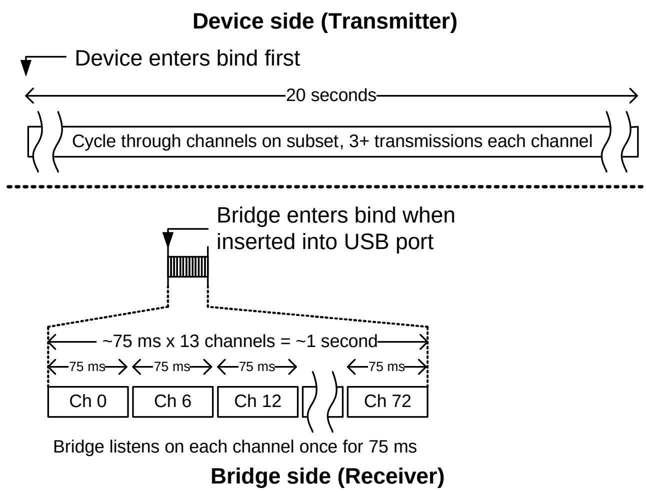
Power-up bind is typically implemented on one side only, with the other side using a button. Generally the timeout will also be kept small. It is possible to use power-up bind with a long timeout if power is rarely cycled. Examples are keyboard and mice for desktop users (Cypress battery life is typically a year or more), sensors in a building control network, or bridges built into some embedded systems.

Obviously there are multiple combinations of power-up on one side or the other, or both, and short or long timeouts. The system architect must carefully consider the behavior that the user will encounter to determine if power-up bind choices are acceptable.

Example 1: Power-up bind on USB bridge, button bind on device

The bridge, since it is USB based, will see frequent power cycles when it is removed from the PC, or when the PC shuts down or hibernates, therefore it will have a short timeout of ~1 second. This is generally not noticeable when compared with the USB enumeration process. The device will use a standard button. To bind, the button on the device is pressed first, and then the bridge is inserted into the USB port. A bind channel subset and reduced PA are also used to generally increase robustness.

Figure 7. Sample Timing for Bridge Power-up Bind



Example 2: Power-up bind on building sensor, button on bridge

Sensors would typically have batteries inserted once every few years. A long timeout on the device side is used so that the basic 2-way button bind behavior is preserved (typical timing per Figure 3). The long timeout would not be intrusive to the device operation. The user can start the bind process on either side: press the button on the bridge first and then insert batteries into the sensor, or the reverse. A bind channel subset is used for robustness, and a higher PA is used in case the bridge is a substantial distance away.

Example 3: Power-up bind on mouse/keyboard, button on bridge

This is somewhat less likely, but presents an opportunity to save cost by removing the buttons on the mouse and keyboard. Those that are not typically powered down can probably use the method described in Example 2. Others, particularly those intended for laptop users, have on/off switches to prevent inadvertent activation during transit. This power-up bind method employs a very brief bind sequence on power-up of the device (1 second or less) and a standard button on the bridge with a long timeout. For general use the ~1 second timeout should be short enough that it is not inconvenient when powering up the product, however it does slightly increase the power consumption of the device in cases where power may be cycled frequently. To bind devices the bridge must initiate the bind process, then batteries are inserted into the mouse or keyboard, or the power switch is cycled. If both devices are being bound the process is repeated for each one.

Advantages

- Using power on to initiate bind on the device side can eliminate the need for one or more buttons, thus saving cost.

Disadvantages

- This process is not necessarily intuitive for the user, therefore it needs to be described in user documentation (which users do not always read).
- There is a slight potential for increased technical support calls for users who do not understand the power-on behavior (Short timeouts require sequencing. Long timeouts make the device appear inoperable until the timeout is over).
- It potentially increases power consumption since the process repeats whenever power is cycled.

Traditional KISSBind

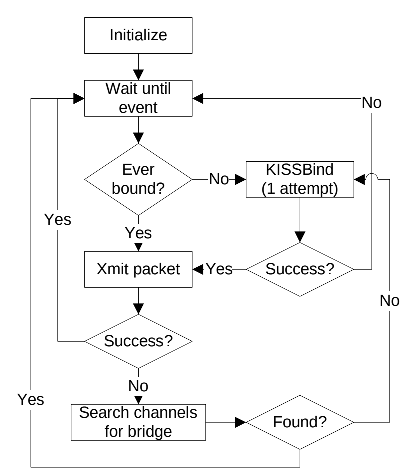
KISSBind is a method developed by Cypress to provide a simple dynamic bind method. It stands for “Keep It Simple Solution”, but is also activated by ‘kissing’ the units—bringing the device in close proximity to the bridge. Note that KISSBind does not necessarily replace other binding methods. It can coexist with one of the manual bind processes described above, thus providing enhanced functionality.

Description

There are a number of things about KISSBind that are very different from the bind methods described thus far. First of all, the bridge can support KISSBind when it is just listening for traffic as part of its normal operation.

On the device side there are two situations where it will enter a KISSBind mode. The first is when it is first powered up without ever having been bound. The second is if it has repeatedly failed to get a response from its bridge. If it does not get acknowledgements and cannot locate the bridge on another channel then it will attempt one KISSBind sequence. If that also fails it will go to sleep. When next awakened it will go through the entire process again until it succeeds somewhere along the way.

Figure 8. Simplified Application KISSBind Flow

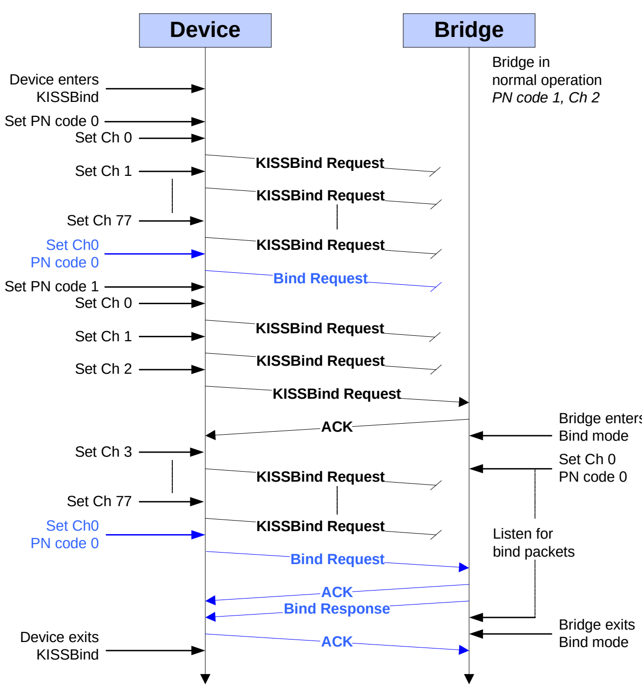


KISSBind also uses range, or more correctly it uses received signal strength, to determine when the device is 'kissing' the bridge. There are actually two sides to this. During transmission the PA level is reduced. On the receive side RSSI is checked. If the RSSI value is not above a certain threshold then the request is ignored because it is assumed that the device is too far away.

The bridge could be using any channel and any PN code. Therefore another unique thing about KISSBind is that the device must try all possible combinations of channel and PN code to locate a new bridge. Checksum seeds can also help differentiate systems, however WirelessUSB LP allows checking both a seeded and zero seed CRC in hardware, therefore zero seed can be used for the KISSBind process.

For KISSBind there are also two types of packets. The first is a special KISSBind request and the second is the bind request. The KISSBind requests are used by the device to search for a possible bridge on all channel and PN code combinations. It does not wait for a response to the KISSBind requests. Instead it periodically goes to channel 0 PN code zero and transmits a bind request at reduced power. Bridges that have received a KISSBind request will automatically go to channel 0 PN code 0 to listen for bind requests. If the device and bridge find one another there, and satisfy the RSSI requirements, then the bind process completes.

Figure 9. Example KISSBind Sequence



Advantages

- KISSBind offers a great deal of flexibility by allowing devices to re-bind dynamically. Whenever an old connection is no longer active a new connection can be established.
- It is conceivable that buttons could be removed from the devices, thus saving cost.
- Using transmit power and RSSI allows some degree of control by the developer. Vendors can choose if they will distinguish close devices or will allow devices far away to bind using KISSBind.

Disadvantages

- This method is not intuitive and has an increased risk of technical support calls. Although conceptually simple—bring the devices close together and they bind—there is one key element that may not be obvious to the user. With battery powered devices, the microcontroller is typically asleep whenever it is not needed. In order to attempt KISSBind requests an action must have been taken by the user to wake up the microcontroller and attempt communication. Therefore it is not sufficient to just hold the device close to the bridge. *While holding the device close to the bridge* the user must press keys, move the mouse, or take whatever action is necessary based on the product functions to make sure that it is awake. The user may not have any idea that this requirement exists and may not even know when the microcontroller is asleep or awake.
- Distance control is coarse, thus increasing the risk of cross-binding. Although the end user has a concept of distance, the actual device can only sense signal strength, as discussed in the range discrimination section earlier. It may be possible for variations of 2X, 3X, or more to exist in certain situations. What this means is that if the target range for KISSBind was established at 12", it may be possible to bind from 6" to 24", or even 3" to 36". Because KISSBind requests go out on every channel and PN code, this might mean that the bridge that responds is not the one that the user intended to bind with. For example, it is conceivable for my mouse to bind to the bridge of the person sitting next to me at a conference table. Calibration of RSSI may help to manage this, but there are still multiple other parameters that are outside of the control of the developer, which can still contribute to significant range variation. It might be possible to employ additional firmware methods to minimize or manage this scenario.
- If accidental binding does occur with an unintended bridge, it may be cumbersome to break. Once bound, normal range parameters are established, so communication could take place to 10 meters or further. The unintended bridge would have to be powered down, or the device and the intended bridge would have to be moved out of range of the unintended bridge.
- During development the ideal received signal strength value is determined based on range from antenna on the device to antenna on the bridge. When inside enclosures, the end user may not necessarily know where the antenna is located. This is especially problematic for keyboards or other large devices. If the developer is trying to control range very tightly, then it may be possible for the bind

range to be shorter than the physical dimensions of the device. Thus the user may try unsuccessfully to bind because in reality the antennas are too far apart even though he has the bridge and device physically close together. This might be mitigated by using an icon, silk screen, or similar method to distinguish the location of the antenna on the exterior of the enclosure, but the user must still know what this means. Increasing the range to manage this might increase the risk of inadvertent binding described in the previous bullet.

- Due to the need to search all channels and PN codes, there is potential for the KISSBind process to take a long time. Based on existing Cypress implementations, it can take a few seconds to complete. In general this is not unacceptable, but there is a small risk that it will be longer than what a user expects, which could lead to confusion about what state the device is in.
- In current Cypress implementations all of the actual bind requests take place on channel 0 and the default PN code. If there is substantial interference on this channel then it may be possible for the bind to fail. There is no channel jumping algorithm. It may be possible to add such an algorithm but it will also increase the time for the process to complete, which could aggravate the condition described in the bullet above.
- When a bridge receives a KISSBind request it stops normal operation and goes to channel 0, default PN code to listen for a bind request. It must stay on this channel for a brief period because the device may still be working its way through a list of PN codes. During this time the bridge will not respond to devices that are already bound to it and attempting normal communication. This should be a very brief period, and should go unnoticed by the end user. This may be most significant if the device does not yet meet the RSSI requirements to bind with the new bridge. It could repeat periodically if the device attempting to KISSBind repeats the process multiple times. It is possible that the user may notice some small impact in performance.
- Power usage increases on the device due to the additional packets that are transmitted. Assuming communications are not lost on a normal basis, thus forcing the device into KISSBind mode, the impact should be very small.
- The code size is increased compared to other methods.

Derivatives

KISSBind on Bridge Only

One implementation that may help to control some of the less desirable behaviors of KISSBind as described above is to create a hybrid where the KISSBind capability is only used on the bridge, but the device uses a button, or even a power-up sequence to initiate bind. This may be useful in situations where the bridge is not normally accessible, such as when integrated within a PC.

Instead of dynamically attempting KISSBind whenever communication fails, it would only be attempted upon a manual action initiated by the user. The bridge behaves as described above. The result is that this would become an infrequent action (maybe one time only), as opposed to the routine occurrence of the KISSBind described above.

Pressing a button (or powering up the device) takes care of the requirement to wake up the microcontroller. Since it is an infrequent operation that is manually initiated it is probably acceptable to take a longer period of time, and even to implement an algorithm to try multiple channels, increasing the probability of success in the presence of interference. Increased power consumption is no longer a problem.

The concerns over range still exist, as well as the end user knowing where the antenna is, but it may not be necessary to control the range as tightly since binding takes place in a user controlled fashion. Pressing the button once more also provides a mechanism to break an inadvertent bind and re-attempt the process. Taking a bridge out of its normal operating mode to respond to a KISSBind request—even if it is not the one the user intends to bind with—is also manageable. The bridge that the user intends to bind with the behavior is expected when the button is pressed, and so acceptable. If it is an unintended bridge that is responding, recall that the interruption should be brief and almost unnoticeable, and since this is now an infrequent operation it should not happen again.

Out-of-Box KISSBind

Coming up with a suitable binding scheme for a specific application may involve mixing and matching some of the principles discussed in the first section of this application note, and even combining elements from some of the binding schemes.

As an example, consider a system binding solution called Out-of-Box KISSBind. The name KISSBind is kept because it preserves the “Keep it simple” philosophy for the end user. ‘Out-of-Box’ is added because it is intended to be static—once bound it stays bound—as opposed to able to dynamically rebind on the fly with traditional KISSBind. Therefore it will be used only for out-of-the-box binding when a device has never been bound before.

Description

It will be possible to bind multiple devices, but only one of any given type, for example one mouse, one keyboard, and others. The bridge must keep track of when each type is bound, such as with a simple flag stored in flash, and will no longer accept KISSBinding from another device of the same type. On the device side it will only send out KISSBind requests if it has never been bound before. Otherwise the same basic algorithm described in the previous section is still used. One possible relaxation is to ease the RSSI constraint to allow binding at slightly longer ranges of around a meter or so. This simplifies binding for the user since the risk of cross binding is small.

Theoretically it is possible to still experience cross binding, but that would mean the user would have to power up the device for the first time in close range to two bridges that have never had that type of device bound before—a rare occurrence. Manufacturers may also want to provide a manual means to control the process, for example for tech support purposes. Therefore a backup manual binding scheme is also implemented.

The backup binding scheme will basically be a modification/combination of power-up bind and button bind. The bridge will have power-up bind implemented as discussed previously—whenever the bridge is powered it will go into a brief (~1 second) backup bind listening interval. The device will have a derivative of power-up bind implemented. When the batteries are inserted and a specific button/key sequence is also followed, it will enter the backup bind mode. As an example, a mouse might require the left and right buttons to be held while the batteries are inserted in order to enter this mode.

The backup bind mode otherwise looks like the power-up bind mode discussed previously, and shown in Figure 7. The device is placed in bind mode first, and then the bridge is inserted into the USB port. If a new device is bound in this way, the bridge will disregard the flag indicating that a device of the same type has previously been bound.

Advantages

- One advantage is reduced cost due to elimination of buttons.
- Simple user experience—user starts to use devices in ‘close proximity’ to bridge and they will bind and function automatically—appears like factory bound without the added manufacturing steps for the vendor.
- Manual backup method allows control of the process and a means to fix cross-bound situations.

Disadvantages

- Slight code size increase since multiple methods are employed
- Risk of cross binding still exists in rare cases
- Slightly increased power consumption, but only until bound
- Time to KISSbind is still slightly longer due to the need to search all channel and PN code combinations
- Bridges in other systems may be briefly interrupted—but again, only until first bound

Conclusion

There are many options for binding devices in a wireless system. Button binding remains a very reliable method for managing this process. There are some creative solutions for providing more robust or lower cost binding implementations, but not all options are appropriate for all systems. Remember that the key question revolves around what type of user experience is intended. If this concept is kept in the forefront it will help guide developers through the decision process.

This application note provided some key concepts and discussed multiple specific implementations, but it is far from all inclusive. Although these methods should solve most common problems, the basic concepts can also be used as a starting point to develop other solutions that are a good fit for specific applications.

Summary Table

Table 1. Binding Methods Summary

Method	Typical use	Advantages	Disadvantages
Factory Bind	Most systems	■ Easiest method with highest chance of successful user experience ■ Low tech support call risk, low support cost ■ No impact to power consumption in battery powered systems ■ Reduced code size if no alternate method	■ Risk of cross-binding on the manufacturing line ■ Potential cost impact for added manufacturing steps ■ Not suitable for systems where additional devices can be sold independent of the bridge
2-way button bind	Most systems—anywhere that both sides are readily accessible	■ Simple system, good user experience ■ Minimal risk of tech support calls ■ Any order, leisurely timing requirement ■ Modest power requirements ■ Nominal code size	■ Small cost impact for button hardware ■ Inadvertent button press ties up system for extended time ■ New wireless users may not understand bind requirements
...Option for software initiation on bridge	Option for systems with robust user interfaces	■ Cost savings for removal of button	■ Not standard or obvious—requires user documentation, tech support call risk ■ Development cost for host software
...Option for sequencing	Where inadvertent button press on one side may be likely and cause inconvenience	■ Reduced timeout—inadvertent bind button presses are imperceptible by user ■ Bind power consumption on that side can be reduced	■ User must follow sequence or bind will fail ■ Higher probability of bind failure—fewer opportunities to converge on channel
Power-up bind	When buttons are inconvenient or add too much cost	■ Cost savings for removal of button	■ Not standard or obvious—requires user documentation and tech support call risk ■ Potentially increased power consumption
Traditional KISSBind	Systems that may need to be dynamically unbound and rebound	■ Dynamic unbind and rebind ■ Potential cost savings by removing buttons (not recommended) ■ Distinguish near and far devices	■ Not intuitive—tech support call risk ■ Fine distance control is difficult, increased probability of cross-binding ■ Difficult for the user to know which part of devices must be KISSed ■ Longer (few seconds) time to bind ■ Chance of bind failure due to interference if only 1 channel used for bind ■ Other bridges may be briefly interrupted ■ Slightly increased power consumption ■ Larger code size
Bridge-only KISSBind	Systems with bridges integrated (button not accessible)	■ Dynamic unbind and rebind ■ Potential cost savings by button removal ■ Distinguish near and far devices ■ Reasonable power consumption ■ Interruption of other bridges possible, but negligible impact	■ Fine distance control is difficult, increased probability of cross-binding ■ Difficult for the user to know which part of devices must be KISSed ■ Long (few seconds) time to bind ■ Larger code size
Out-of-box KISSBind		■ Potential cost savings by button removal ■ Simple user experience ■ Manual backup when better control needed	■ Larger code size ■ Small risk of cross binding ■ Increased power consumption—but only until bound ■ Long (few seconds) time to bind ■ Other bridges may be briefly interrupted—but only until bound

In March of 2007, Cypress recataloged all of its Application Notes using a new documentation number and revision code. This new documentation number and revision code (001-15443, beginning with rev. **), located in the footer of the document, will be used in all subsequent revisions.

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